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CONSUMER PACKAGING IN CALIFORNIA

by

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CONSUMER PACKAGING IN CALIFORNIA[1]

G. L. Mehren,[2] L. L. Morris,[3] and Wendell Calhoun[4]

Summary

1. Compared to the total, there is relatively little consumer packaging of fruits and vegetables under way. Vegetables are being packaged in larger volume than are fruits. However, only spinach, tomatoes, salad mixes and soup mixes are commonly packaged throughout the state.

2. Most consumer packaging at present is being done by commercial packers and is largely for local (2 to 3 days) distribution. Except for one cooperative group of growers, very little packaging is being done by producer or retailer interests.

3. Developmental and research work with a view toward long-distance shipment of prepackaged fruits and vegetables is under way. This work is concentrated on vegetables. Development of shipping-point packaging for distant sale may have important effects upon the California fruit and vegetable industries.

4. Most enterprises concerned -- from producer to package manufacturer, seem to be proceeding with caution. A need for factual information is obvious.

5. The proper role of the Experiment Station in this development is not clear. An all-inclusive project on consumer packaging of fruits and vegetables does not seem desirable. However, cooperation between various interests within the Experiment Station, the research groups of the United States Department of Agriculture and industry agencies should be fostered. The research agencies need to acquire experience themselves before they will be in a position to make major contributions. To this end, cooperation in making trial shipments, and in following "pilot-type" operations should be given serious consideration. Help in solving specific problems as they arise is probably more desirable than initiating a project designed to cover the entire subject. From the viewpoint of economics, data could be obtained to measure several aspects of consumer demand. It is considered too early to inquire into the probable effects of packaging upon market channels, handling methods, structure of competition or costs, despite the fact that consumer packaging will probably have important effects upon these matters.

1/ This is a preliminary report based upon a short survey. The questions at issue were: What is the extent of current packaging operations in California? What problems must be solved before packaging expands? What are the probable lines of development of packaging? How can the research facilities of the Experiment Station and the United States Department of Agriculture best be used in this development?

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PRESENT STATUS

Products Packaged

Very little consumer packaging is under way in California in proportion to the total supply of fruits and vegetables grown in the state. Although most fruits and vegetables have been packed in consumer units at one time or another, the practice has become established in only a few cases. Vegetables are receiving much more attention than are fruits. Practically all packaging has been for distribution within the state.

Spinach is being packaged in greater volume than any other fresh commodity. It is estimated that over 50 per cent of the spinach in the Los Angeles area is marketed in transparent consumer packages and that the same percentage is approached in the Bay area. Established enterprises are located in the Los Angeles area, the Bay area, and in the San Benito, Salinas, and San Joaquin valleys.

Salad and soup or stew mixes are being packaged primarily by the same agencies that package spinach. The salad mixture is composed largely of shredded cabbage. The soup mixture also contains a considerable quantity of cabbage together with other vegetables such as carrots, turnips, celery, onions, and parsley.

Tomatoes are being packaged on a fairly wide scale during the season that the supply is coming from out-of-state areas. This is being done as a subsidiary operation to the necessary ripening and repacking operations of receivers at the destination markets.

The consolidation of onions and potatoes into consumer units varying from 10 to 25 pounds has been practiced for several years. This is done at shipping point, at the wholesale warehouse, and at the retail store.

The popularity of packaged spinach can be attributed to several factors. The sorting and washing improves its appearance and reduces the work of the housewife. A large amount of waste material is eliminated. Year-round production results in a fairly stable supply and makes possible the use of the packaging facilities throughout the year. There is a year-round demand for the product, although it slacks off during the summer months. This relatively constant supply and demand are associated with fixed-price policies in buying and selling. Most of these advantages probably could be realized for certain other vegetables such as carrots, cauliflower, celery and lettuce.

Aside from these vegetables, several have been packaged on an experimental or trial basis with a view toward expansion into commercial scale. Celery has been packaged in both the Bay area and the Los Angeles area. Lettuce is being packaged on a fairly large scale in the Los Angeles area by a cooperative association of grower-shippers. Cauliflower and broccoli have been packaged to some extent. Brussel sprouts, carrots, asparagus, and potatoes which have been peeled and processed are under consideration but to date little or no packaging has been done.

In some instances packaging has been discontinued. This is true of some retail stores that attempted to package at the place of sale. At least one shipper has discontinued the packaging of cauliflower and another has dis-

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continued radishes. Operations have been terminated for a variety of reasons: no price differentials over bulk sale; interference with other operations, such as mixed-car sales of broccoli; inadequate supply of the product year-round; need to pack too many units to make up a practicable package.

Current operations indicate that these products which can be kept high in quality, for which some processing is possible or weight elimination is significant, and which have both year-round demand and production, offer greater opportunity for consumer packaging.

Except for the spinach operations, there seems to be much caution among the packers with an apparent wish that others undertake the preliminary and experimental work, particularly for shipment to distant markets.

Types of Enterprises

Consumer packaging has been undertaken by all segments of the industry from grower to retailer. In fact, the question as to where and by whom the packing will be done is probably the biggest issue that the industry faces.

Growers and shippers have undertaken some packaging operations but for the most part their activities have been confined to collaboration in research and developmental activities. Although considerable activity by growers and shippers is anticipated, at present a negligible amount of packaging is being done by individual firms. In some cases consumer packing operations have been discontinued by shippers. A cooperative made up of several large grower-shippers is engaged in developmental packaging on a commercial scale.1/

Commercial packers specializing in one or a few products account for most of the volume of vegetables now packaged. To illustrate the diversity of these operations, in one spinach-packing enterprise the consumer packing operation is a side line for a wholesale vegetable dealer and in another the packing is a side line for a spinach cannor. A large tomato importing enterprise has recently begun operations at Nogales, Arizona and comtemplates shipments into western cities.2/

A few retail outlets are doing some packaging at the place of sale. However, this practice seems to be decreasing. The retail chain stores are doing some packaging at their wholesale level. This is true for repacked tomatoes and for potatoes. At least one chain store company is contemplating consumer packaging of various fruits and vegetables for their retail outlets.

In addition to these enterprises there is considerable activity of a research or exploratory nature. The Western Growers Association has formed a research group and set up a private laboratory at Pasadena. This group is conducting holding tests and plans soon to undertake transit tests and pilot-plant operation. The manufacturers of packaging materials are cooperating with this

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1/ Lettuce is being packaged as a commercial venture and the addition of several other lines is contemplated.

2/ The Packer. April 5, 1947

and other agencies in making exploratory tests and trials.

Methods of Procurement

Some spinach packers contract their acreage in advance and exercise control over harvesting operations. Others buy through regular wholesale channels, sometimes using spinach from out-of-state areas. The cooperative association mentioned above is supplied by its own members who have committed themselves insofar as possible to provide a stable supply. Winter tomatoes that are packaged are procured through the regular wholesale channels. It would appear that a stable supply assured either by contract or by entering into production is probably necessary for the commercial packer. Those retailers who are doing some packaging procure their commodities in the usual manner.

Methods in Use

Packaging methods, facilities, and techniques vary widely with the different products and agencies. With a few notable exceptions, the operations are on a rather primitive level. Some spinach operations are highly mechanized with hand labor being used only for sorting, trimming, and placing in the bag. Tomato operations have a wide range in combinations of mechanization and hand labor. The packaging operations at retail stores have been almost entirely on a hand basis. The consequent high cost has discouraged packaging at the retail level.

Three general types of packages are used for consumer packaging. Bags of transparent cellulose film are used for spinach and salad and soup mixes. These bags are usually closed by metal staples. Open top bags made of a transparent rubber hydrochloride film have been used on a commercial scale for celery.

A second method of packaging consists of placing the vegetable in a paper tray or "boat" and then overwrapping the unit with a transparent film. Machinery such as has been used in the baking industry is used for this type of packaging.

A third type of package consists of a cardboard box with a transparent film for a window. This package is commonly used for tomatoes.

In addition to the above, a method is under consideration whereby the commodity is contact-wrapped and then the wrapper film is sealed.

The mechanical equipment being used in packaging operations varies greatly. Estimates of the investment necessary for packing a given commodity would be next to meaningless.

Distribution Methods

Methods of sale vary. However, where possible the product is packaged to orders already received. Due to the high perishability of the product, it is necessary to restrict the pack to the estimated daily requirement. The regular wholesale market outlets are being used to a considerable extent as an outlet for packaged vegetables. In fact, some packaging is being done on the wholesale

markets in both the Los Angeles and Bay areas.

Some demand promotion is being done by salesmen contacting the retail outlets. Apparently little or nothing has been done to promote demand at the consumer level.

The distribution of packaged vegetables has been limited in extent and area as compared to the distribution given wholesale packages. In general, distribution is limited to a truck radius. However, air shipment is being used to a limited extent. For example, spinach is regularly flown to several markets within a radius of one thousand miles. In so far as was determined, no company regularly ships carloads from California. Since at present refrigeration during transit and retailing is usually nonexistent, the only control of quality is speed of handling and recovery of unsold stock from the retailers. The limitation of sales to the retailer probably operates to prevent gluts and unsold merchandise of poor quality.

All operators apparently desire a stable price both in respect to buying and selling. Even those packers who are buying on a fluctuating wholesale price are attempting to maintain a fixed price to the retailer and apparently desire the retailer to maintain a fixed price to the consumer. There has been at least one attempt to establish the wholesale selling price by application of a mark-up formula based upon f.o.b. price of unpackaged produce, with a fixed margin for packaging.

Retail Handling

Very little time was spent with retailers. However, it is apparent that the physical methods used to display and merchandise packaged produce vary as much as do the methods used for unpackaged fruits and vegetables. A few stores have refrigerated display cases but they are the exception rather than the rule. In general, the packaged commodities are displayed alongside the bulk produce at room temperature.

A one day survey was made of 29 retail stores in Sacramento to determine the extent to which packaged vegetables were being carried. The observations are tabulated in the following table.

TABLE 1

Displays of Packaged Spinach, Salad Mix and Tomatoes
by 29 Retail Stores in Sacramento, April 10, 1947

Size of store	Number of stores visited	Number of stores displaying packaged		
		Spinach	Salad mix	Tomatoes
Small	7	1	1	0
Medium	16	7	9	7
Large	6	2	2	3
Total	29	10	12	10

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With the exception of soup mix in one store, spinach, salad mix and tomatoes were the only vegetables displayed in consumer packages. Only about one third to one half the stores were displaying these commodities on this date.

Physiological and Technological Aspects

There has been much discussion concerning the desirability of various films as packaging materials. However, there are practically no experimental data available concerning the benefits or harm to be expected from enclosing any given vegetable in films of various permeabilities under various conditions of temperature, humidity, and storage time.1/

In packaging at shipping point for local distribution, any one of several films can be utilized for packaging most vegetables. Perhaps some may have advantages over others, but most of the available films can at least be tolerated for the short periods necessary for local marketing. In short, the problems connected with local packaging seem to be mainly of a physical and economic nature. However, there are some vegetables that are so perishable that it would appear doubtful that consumer packaging could result in the delivery of a high quality product under the present methods of wholesale and retail handling even though the marketing period be limited to a short one. Sweet corn, shelled peas, and shelled limas would fall in this class. It is very doubtful that the consumer package as such contributes to the storage life of any of the vegetables now packaged. However, initial selection of high grade produce, careful grading, rapid handling, and removal of deteriorated produce from the stores are all practices which tend to enhance the quality of packaged vegetables. The additional handling involved in washing, sorting, and packaging vegetables undoubtedly contributes to a more rapid rate of deterioration. The preparation of a salad or soup mixture undoubtedly increases the perishability of the components.

The packaging of vegetables in wholesale units for breakdown and repacking at or near the point of sale is another possible development. Under such conditions, rapid and desirable handling after packaging will be necessary -- especially if the transit period is a long one. The commodity, after transit, will have exhausted part of its storage life and initial quality and hence will be more perishable than a commodity pre-packed at point of production for local distribution.

A third possible development, and one that is of primary interest to California producers, is the pre-packing at shipping point for sale at distant (in time) markets. Such a procedure poses many physical and physiological questions and probably will be established only after considerable experience with local packaging and after much experimental and developmental work. Due to the additional time involved, methods of precooling and refrigeration assume a major role. Continuous refrigeration will be needed for many vegetables. The characteristics of the packaging material and the master container used will probably be more critical under these conditions than for local packaging.

1/ The relationship between packaging and waste is discussed in the Packer of March 29, 1947. The Packer article "'Normal' Food Waste -- Is It Irreducible?" is a condensation of an article by C. W. Hauck and W. L. Lonox of Ohio State University.

Although the first consideration will be to determine what materials can be used, there is a possibility that some packages may actually contribute to the total storage life of some vegetables.

Considerable experimental and developmental type of work is under way on consumer packaging of vegetables. Much of the commercial packaging under way also is experimental, or, at least developmental in nature.

As mentioned above, the Western Growers Association has established a research group which is working cooperatively with the staff of the California Institute of Technology and with industrial interests concerned. The work of this group is broad in scope covering a study of storage life under various temperature and humidity conditions, effect of gas concentration, methods of decay control, and techniques of washing, drying and packaging. Only holding tests are being conducted at present, but pilot-plant packaging and transit tests are planned. This group is progressing on the assumption that the practice can be made economically sound. Emphasis is being placed on the technical aspects of packaging operations. This group should ultimately be able to provide both practical and basic information.

Lack of information on the characteristics of various packaging materials is one of the limiting factors to the prepackaging of fruits or vegetables for long-distance shipment. It will be necessary to conduct many storage tests in which vegetables and fruits are packaged and held under controlled temperature conditions. Observations should include weight loss, storage life, and in some cases, chemical changes. The research group of the Western Growers Association is doing controlled work of this nature. It appears that the Experiment Station could assist materially in developing information of this type.

Along this line, information is needed concerning the value and limitations of holding fruits and vegetables in atmospheres of various CO_2 and O_2 concentrations. Research of this nature is under way or contemplated by commercial interests. The work of the Experiment Station, especially in the vegetable field, could well be expanded in this regard.

Many technical problems of an engineering nature confront the industry. Progress in this field is another factor limiting the long-distance shipment of consumer-packaged vegetables. Work of this nature is receiving the attention of many allied interests and the work on vegetables is concentrated in the Western Growers' Assocation Research Group. The only obvious or requested role of the Experiment Station was assistance in conducting trial shipments. This work will undoubtedly be in cooperation with the Bureau of Plant Industry.

Economic Aspects

Despite the small scale of current consumer-packaging operations in California, there are already clearly-apparent pressures which will almost inevitably lead to its expansion. Packaging offers profit opportunities to retailers, distributors, and to concerns presently engaged in canning, freezing or dehydrating. It should permit retailers to introduce into their produce departments the self-service methods now widely used in handling other foodstuffs. Demand for some packaged products will probably be high enough to cover additional costs of packaging, especially those products for which the

need of home preparation is diminished. Uniformity of quality should be easier to maintain and the damage, waste, and contamination from handling py purchasers should be lessened. Shipping-point distributors should be able to eliminate much waste weight and off-quality produce before transit. Large-scale operation should make possible the use of mechanical techniques for packaging not readily adaptable by retailers or by wholesale receivers in terminal markets. With centralized packaging at shipping point, distributors should be able more effectively to control grade, size, sanitation and volume of shipment. Product differentiation, advertising and market control should be facilitated. Packaging of vegetables as a by-product to freezing, canning, and dehydration operations is already being investigated as a means of decreasing overhead costs per unit of output.

If this expansion of shipping-point packaging occurs, it is almost certain that major changes in methods of marketing will also occur. Some functions will be shifted, new functions may be introduced and others eliminated. The introduction of packaging machinery will change the kind and volume of labor needed in produce marketing. Shifts in market channels similar to those associated with the introduction of packaging in other lines of foodstuffs can be expected to occur in produce marketing. Transportation will be speeded and refrigeration facilities expanded.

In most staple-food lines in which the processors have packaged and branded the product, they have also extended their influence over the marketing process backward toward original production and forward toward final consumption. The first signs of this same development are appearing in the packaging of fruits and vegetables. Packagers control seed, planting, harvesting and price by contract with growers. Continuous efforts are made to eliminate fluctuations in the buying prices of their products or in the selling prices of the packaged product or both. Processors appear to be willing to collaborate in periods of short supply or other difficulties. Some of them attempt to dampen daily price fluctuations and to regulate quality within narrow tolerances. Processors apparently want both the retail trade and consumers to become accustomed to uniform quality and price, both of which are to be associated with the brand. Removal of deteriorated products from retail stores by processors is intended both to control quality and to support price-maintenance programs. They recognize that deterioration in quality or appearance of a packaged and branded product may seriously depress demand for it, from which recovery may be very slow. Thus, as in foodstuffs for which packaging and branding have been introduced at the processing level, price, quality and volume control have quickly been introduced. With the low output thus far attained, packagers have not yet considered the applicability of fair-trade laws setting price floors or permitting resale price-maintenance contracts. No extensive advertising has been undertaken, although at least one California packer is considering the desirability of directing his advertising henceforth to consumers rather than to wholesalers.

Extension of packaging may also have repercussions upon the functions now performed by wholesalers and retailers as well as upon the degree to which they can influence the marketing process. In other lines, the packagers of foodstuffs have gone directly to the consumers by means of advertising. As a result, the functions of the wholesalers and retailers have been constricted and their influence upon the producer has been lessened. Retailers no longer greatly affect the demand for many packaged products, and some independent wholesalers have been reduced almost to the status of branch

houses or warehouses. For example, grocers have little choice in respect to carrying many branded products like cigarettes and virtually no leeway in pricing them. Packaging in consumer units at shipping-point, if associated with the expected extension of stable-price policies, will also constrict the price-making or price-registering function which is presently so important a phase of the wholesale produce market. Retail distribution will also be affected if shipping-point packaging of fruits and vegetables expands. The development of the refrigerated, self-service package store will probably be hastened. While additional costs in handling and refrigeration will be incurred by the retailer, savings in labor and spoilage costs should at least partly compensate for the increase. If the packager is able successfully to differentiate his product and to carry his advertising directly to consumers, he will effectively command consumer demand. The larger is the scale of the packaging operations, the greater will be the influence of the packager and the greater will be the changes in functions, methods of handling and channels of trade.

Equally important changes in the structure of competition may occur.[1/] At present, many shippers of fresh fruits and vegetables can do little to affect market price. About the only factor related to profit which they can control in the short run is the amount marketed. However, if processing develops on a large scale, the volume of purchases by individual packers may become sufficient either directly or indirectly to affect selling prices in the field. There is already some evidence that the competitive status of the various agencies involved in produce marketing may shift if large scale packaging develops.

There is probability that some of these changes will occur within the next several years. Changes in marketing structure may be similar to those which have occurred in other lines of packaged foods. The effects of these changes upon the marketing mechanism will spread to growers, handlers and consumers. When they occur they will offer highly interesting and important fields of research. However, until they do actually occur, and until the technology of packaging shakes down into reasonably stable molds, they offer little if any research opportunity. At present there is a line of precedent in other products, and the first bare indications that the same line of development may be reproduced in packaged fruits and vegetables. But there are a large number of directions along which packaging may be developed. It is far too early to investigate these changes in market structure.

Two other lines of inquiry suggest themselves in the economic aspects of packaging -- costs and demand. It would be useful to determine the additions to total costs attributable to packaging of fruits and vegetables at various levels of the marketing process, by various techniques and at various scales of output. This could probably be done for the few enterprises continuously operating now. However, techniques of packaging are yet unsettled. Shipping point packaging and packaging at terminal markets distant from points of production are in the very earliest stages of development. There are a few small scale, experimental or pilot-type operations in which Experiment Station

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1/ Structure of competition is defined in terms of the degree of product differentiation; the degree to which the volume of any single seller can affect market price and the degree to which freedom of entry into the industry prevails.

personnel might collaborate. But until some stability is introduced into methods of packaging and shipping, cost comparisons would be almost without meaning. This stability must await the solution of several technological problems and the development of new marketing facilities.

There does appear to be an opportunity for research into the demand for packaged products. A series of questions can be posed and for most of them it should be possible even at this early stage to find answers. What factors affect the price of packaged fruits and vegetables at retail? How are such factors interrelated? What is the effect of condition of product upon level of demand? How does the degree of preparation for use affect the differential between packaged and bulk products? How does the display of the products affect the differential between the two types? How effective is branding in obtaining a price differential? Are there any significant seasonal variations in the level of demand for packaged products?

It might be possible to collaborate with one or more of the agencies currently packaging products for retail sale within the state. If it were also possible to establish connections with several grocers retailing the product, controlled experiments could provide data to answer these questions. It probably would be necessary to effectuate an agreement by which to adjust display, quality and price within reasonable limits, and to obtain data on the relationship of packaged and bulk demands. Similar studies could be worked out as other phases of packaging become sufficiently settled to justify research. No over-all project encompassing all problems involved in the consumer packaging of fruit and vegetables is desirable at present.

NOTES ON CERTAIN VEGETABLES

The physiological characteristics of the vegetable may largely determine the success of prepackaging in relatively tight containers. Although it will be necessary to make tests under commercial conditions, there is some experimental information available that may be of value in predicting and explaining results. Following are notes on spinach, head lettuce, tomatoes, celery, salad and soup mixes, carrots, asparagus, cauliflower and broccoli. Although this material is incomplete in many respects, it may serve to point out the many physiological factors that are involved.

In the following, "storage life" means the time required for the freshly harvested vegetable to reach an unusable condition. It is an approximate rule that the storage life of many vegetables is doubled or tripled by lowering the temperature about 18 degrees Fahrenheit within usual temperature limits.

It is an established experimental fact that a reduction in oxygen-content of the atmosphere can result in either benefit or harm to the vegetable depending upon the concentration and time involved. In like fashion, the carbon dioxide concentration may be either beneficial or harmful. When a vegetable is enclosed in a transparent consumer package, there is a definite tendency for the oxygen to be reduced and the carbon dioxide increased within the package. It will be necessary to evaluate this effect under commercial conditions.

Spinach

Storage Life.-- Two to three days at 70 degrees Fahrenheit; five to six days at 50 degrees Fahrenheit; ten to twenty days at 32 degrees Fahrenheit.

Causes of Deterioration.-- Water loss; yellowing; decay.

Storage Requirements.-- High relative humidity and 32 degrees Fahrenheit optimum; package-ice desirable for bulk spinach; refrigeration required for any marketing period exceeding two days.

Effect of Low Oxygen.-- It has been reported (8)[1] that spinach held in 0.8 per cent O_2 for three days at 68 degrees Fahrenheit was superior in appearance and taste to that held in normal air. Low O_2 concentration has resulted in lower respiration (8) and better retention of ascorbic acid (10). Changes in O_2 concentration between 5 and 21 per cent seem to have little effect on O_2 consumption or CO_2 production.

Effect of High Carbon Dioxide.-- Very little work is published on this. One set of tests (2) indicates that spinach is more tolerant of high CO_2 than certain other vegetables; a concentration averaging about 50 per cent (80-30) for a two day period at 65 degrees to 40 degrees Fahrenheit did no harm to spinach. Another investigator (14) observed injury when spinach was held for four days in a concentration of 20 per cent CO_2 at 39 degrees Fahrenheit, 50 degrees Fahrenheit, and 59 degrees Fahrenheit. It has been reported (10) that CO_2 will hasten ascorbic acid loss at 75 degrees Fahrenheit but has little or no effect at 50 degrees Fahrenheit.

Magnitude of Respiration.-- The respiration rate of spinach is high compared with most other vegetables. The respiration rate decreases with storage. Following are approximations based on data reported by Platonius (7):

Temperature	Mgr. CO_2 per Kg.-Hr.	B.t.u. per ton per day	Pounds of ice per ton per day
Degrees Fahrenheit			
75	275	60,500	420
50	60	16,500	115
33	15	4,125	29

Preparation for Packaging.-- Spinach is washed; sorted for foreign material, dead leaves, etc.; roots and coarse stems are removed; and excess water removed before packaging. Precooling would undoubtedly be of value.

Elimination of Weight.-- The amount of unusable material removed when spinach is pre-packed varies considerably. Estimates by pre-packers fall in the range of 30 to 60 per cent. Rasmussen and Platenius (12) have estimated that 10 ounces of packaged spinach is equivalent to 24 ounces of bulk

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1/ Numbers in parenthesis refer to reference citation at end.

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spinach.

Effect of Packaging.-- There are practically no data available on the effect of consumer packages on storage life or nutrient content of spinach. The opinion has been expressed that "store life" is lengthened by packaging. Others (12) hold that pre-packing spinach renders it more perishable. Both results probably occur under different commercial conditions. The package retards water loss on the store shelf and may possibly have some benefit by creating a favorable atmosphere. The extra handling and bruising probably contribute to the deterioration of the spinach. The net result of packaging spinach is probably a somewhat lengthened storage life under most conditions.

Platenius (9) has reported that none of the films commonly used are sufficiently permeable to oxygen to permit of normal respiration by spinach in a sealed bag.

Conclusions.-- The scale of spinach packaging indicates that it is already a well established product. Partial preparation for home use is undoubtedly the major factor in its popularity. Methods of handling for marketing periods of more than two or three days are yet to be worked out. Improvements in local distribution methods would seem desirable since the packaged spinach observed in retail stores often leaves much to be desired.

Holding tests to determine the possibilities and limitations of various films under different temperatures and for various periods are needed. Appearance, taste, and nutrient content should be considered. The present method of closing the bag by staples may be superior to a tight seal. If a tight seal is used, vent holes should be provided unless such are shown to be unnecessary. Methods of packaging are sufficiently settled to make cost of packaging studies possible. Sufficient data could be collected to measure various aspects of consumer demand.

The physiological characteristics of Swiss chard and other greens are closely similar to those of spinach.

Head Lettuce

Storage Life.-- Three to four days at 70 degrees Fahrenheit; six to ten days at 50 degrees Fahrenheit; fifteen to twenty-five days at 32 degrees Fahrenheit.

Causes of Deterioration.-- Wilting, discoloration, decay.

Storage Requirements.-- High humidity and 32 degrees Fahrenheit desirable. Refrigeration essential for all marketing periods exceeding two days.

Effect of Low Oxygen.-- Very little experimental work published. Nelson (6) has reported that redheart and sunken lesions on outer leaves were caused by a deficiency of O_2.

Effect of High Carbon Dioxide.-- It has been reported (2) that a high CO_2 content maintained for two days was not harmful to head lettuce of the Iceberg variety. However, Thornton (14) has reported that a CO_2 content as low as 13 per cent has produced injury on head lettuce when held for one week at 32 degrees or 39 degrees Fahrenheit. The lettuce became soft, lost crisp-

ness and soon rotted when exposed to this concentration of CO_2.

Magnitude of Respiration.-- The respiration rate of lettuce is more or less intermediate when compared with other common vegetables. Following are some approximations based on data of Platenius (7):

Temperature	Mgr. CO_2 per Kg.-Hr.	B.t.u. per ton per day	Pounds of ice per ton per day
Degrees Fahrenheit			
75	65	14,300	99
50	20	4,400	31
33	10	2,200	15

Preparation for Packaging.-- Washed, trimmed, and excess water removed. Precooling desirable.

Elimination in Weight.-- Maximum of about 10 per cent.

Effect of Packaging.-- Tests conducted in Florida (13) showed that a pliofilm wrapper aided in the retention of weight, color, texture, and palatability of lettuce held at 37 degrees Fahrenheit or 70 degrees Fahrenheit. The thinnest wrapper gave the best results and folded bags were superior to sealed bags. Cellophane is being used as a heat-sealed overwrap for lettuce for local distribution. No deleterious results have been reported.

Conclusions.-- If a sealed package is used for long marketing periods, some venting may be required. Apparently a heat-sealed cellophane wrapper can be used for local distribution.

The fact that head lettuce is in fairly constant supply and demand should contribute to its adaptability to consumer packaging. However, there appears to be little gained by way of preparation for the table. The effect of packaging upon table quality remains to be demonstrated. Sufficient volume has been reached to make consumer-demand studies possible.

Tomatoes

Storage Life.-- Mature green: five to ten days at 75 degrees Fahrenheit; ten to twenty days at 65 degrees Fahrenheit; twenty to thirty days at 55 degrees Fahrenheit (minimum temperature). Pinks: three to four days at 75 degrees Fahrenheit; four to eight days at 65 degrees Fahrenheit; eight to fifteen days at 55 degrees Fahrenheit.

Causes of Deterioration.-- Normal ripening, softening, shrivelling, decay.

Storage Requirements.-- Subject to "chilling injury". Should not be exposed to temperature below 50 degrees Fahrenheit for prolonged periods (over five to eight days). Will not ripen above about 77 degrees Fahrenheit. Limits of storage 50 degrees to 75 degrees Fahrenheit. Limits of ripening

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55 degrees to 75 degrees Fahrenheit.

Effect of Low Oxygen.-- Can prevent ripening of mature green and cause physiological breakdown.

Effect of High Carbon Dioxide.-- High CO_2 concentrations for a period of two days have been reported to retard ripening slightly (2). Thornton (14) reports that the tomato is very susceptible to carbon dioxide injury. A concentration of 10 per cent maintained for four days at 32 degrees, 39 degrees, 50 degrees or 59 degrees Fahrenheit proved harmful. Complete breakdown of the tomato was reported.

Magnitude of Respiration.-- Compared with other vegetables, tomatoes have a relatively low respiration rate. Following are some approximations based on data of Platenius (7):

Temperature	Mgr. CO_2 per Kg.-Hr.	B.t.u. per ton per day	Pounds of ice per ton per day
Degrees Fahrenheit			
75	40	8,800	61
50	12	2,640	18
33	5	1,100	8

Preparation for Packaging.-- Washing and possibly waxing.

Elimination of Weight.--None Possible. An increase might occur.

Effect of Packaging.-- Tests with pliofilm in Florida (13) gave only beneficial results from wrapping tomatoes. Ripening was retarded somewhat. There have been some tests using ordinary paper wrappers. The results are conflicting but it seems logical to conclude that ordinary paper wrappers have no practical effect on ripening. However, under commercial conditions, improper ripening has been observed in consumer packages that were sealed. On the other hand, accelerated ripening has been reported (3) following wrapping--this was attributed to the trapping of a volatile material.

Conclusions.-- It is doubtful that the present method of putting tomatoes in a cardboard box with a cellophane window has any practical effect on their physiology. However, a couple of holes in the sides of the box for ventilation would do no harm and might be of value. If a sealed overwrap is used, some ventilation should be provided unless tests show that this is not needed.

Tomatoes must be at least breaking in color before packaging in cartons containing 3 or 4 fruits since a given lot of mature green fruits ripen very unevenly. Wrapping individual fruits in a transparent film may have practical possibilities for mature green tomatoes.

Tests are needed to determine the effect of trapping volatiles such as

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ethylene that are given off by tomatoes during ripening.

Data could be obtained for cost or demand studies.

Celery

Storage Life.-- Five to ten days at 70 degrees Fahrenheit; fifteen to twenty-five days at 50 degrees Fahrenheit; and sixty to ninety days at 32 degrees Fahrenheit.

Causes of Deterioration.-- Water loss, browning of cut surfaces, decay.

Storage Requirements.-- High humidity and 32 degrees Fahrenheit. Refrigeration required for marketing periods exceeding four or five days.

Effect of Low Oxygen.-- No data available.

Effect of High Carbon Dioxide.-- Thornton (14) has reported that 25 per cent CO_2 produced injury at 50 degrees Fahrenheit but not at 32 degrees or 39 degrees Fahrenheit. A concentration of 50 per cent produced injury at 32 degrees and at 39 degrees Fahrenheit.

Exposure for three days to an atmosphere in which the CO_2 averaged 50 per cent resulted in slight injury (2). Even 20 per cent gave very slight browning of the vascular tissue.

Magnitude of Respiration.-- Celery is intermediate to low in respiration rate. The following is based on data of Pentzer included in United States Department of Agriculture Circular 278.

Temperature	Mgr. CO_2 per Kg.-Hr.	B.t.u. per ton per day	Pounds of ice per ton per day
Degrees Fahrenheit			
60	27	5,960	41
40	12	2,600	18
32	3	700	5

Preparation for Packaging.-- Washing, trimming, removal of excess water. Pre-cooling would be desirable during warm weather.

Elimination of Weight.-- Would depend on trimming practiced. Probably about 20 per cent (5).

Effect of Packaging.-- Tests with pliofilm conducted in Florida (13) indicated that an over-all wrap or a stretch wrap resulted in a marked retention of market and table quality. Partial wrappers of parchment paper have been used for several years. Work (16) reports that full coverage with a parchment paper wrap resulted in retention of table quality. Waxed paper wraps were also of definite value.

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Conclusions.-- The close trimming of celery leaves should contribute to its storage life. Continuous refrigeration would be desirable, but prepackaging for local distribution would have advantages under present methods of display. A tight seal should be avoided for long marketing periods until more is known of the possibilities and limitations of various films.

Salad and Soup Mixes

Storage Life.-- One to two days at 70 degrees Fahrenheit; two to four days at 50 degrees Fahrenheit; and six to twelve days at 32 degrees Fahrenheit.

Causes of Deterioration.-- Weight loss, development of slime and decay, discoloration, possibly loss of nutritive value.

Storage Requirements.-- High humidity and 32 degrees Fahrenheit. Refrigeration required for periods exceeding two days.

Effect of Low Oxygen.-- No data; probably desirable down to at least 5 per cent.

Effect of High Carbon Dioxide.-- No data; probably desirable up to 15 to 20 per cent.

Magnitude of Respiration.-- No data; probably intermediate compared with other vegetables.

Preparation for Packaging.-- Washing, trimming, slicing or dicing, removal of excess water.

Elimination of Weight.-- Probably 20 to 30 per cent of the weight of the bulk vegetables comprising the mixture.

Effect of Packaging.-- The net result of the complete procedure is to make the components much more perishable. However, the final product could be handled only in packaged form.

Conclusions.-- Work is needed to determine the storage life and loss of nutritive value of these mixtures under various conditions.

Carrots -- Topped

Storage Life.-- Five to fifteen days at 70 degrees Fahrenheit; twenty to forty days at 50 degrees Fahrenheit; and sixty to ninety days at 32 degrees Fahrenheit.

Causes of Deterioration.-- Water loss, decay, sprouting, rooting.

Storage Requirements.-- High Humidity and 32 degrees Fahrenheit optimum.

Effect of Low Oxygen.-- An O_2 concentration of 2.3 per cent at 68 degrees Fahrenheit, resulted in serious injury to carrots (8); but 4.8 per cent at the same temperature gave no injury.

Effect of High Carbon Dioxide.-- Thornton (14) found carrot roots very tolerant of high CO_2. Others (1) (2) have reported a beneficial effect from high CO_2.

Magnitude of Respiration.-- Carrot roots have a relatively low respiration rate compared to many other vegetables. The following are approximations based on data of Platenius (7):

Temperature	Mgr. CO_2 per Kg.-Hr.	B.t.u. per ton per day	Pounds of ice per ton per day
Degrees Fahrenheit			
75	40	8,800	61
50	15	3,300	23
33	6	1,320	9

Preparation for Packaging.-- Removal of tops, washing, possibly waxing.

Elimination of Weight.-- Approximately 20 per cent when compared with bunched carrots.

Effect of Packaging.-- Pliofilm bags and wrappers have been reported to be beneficial in retarding loss of quality of both topped and bunched carrots (13).

Conclusions.-- A beneficial rather than harmful effect could be expected from packaging topped carrots in the materials commonly used. The packaging of carrots should present fewer problems than most vegetables. However, aside from retention of quality, few advantages could be visualized.

Asparagus

Storage Life.-- Two to three days at 70 degrees Fahrenheit; five to eight days at 50 degrees Fahrenheit; and fifteen to twenty five days at 32 degrees Fahrenheit.

Causes of Deterioration.-- Fiber development, loss of sugar, water loss, opening of tips.

Storage Requirements.-- High humidity and 32 degrees Fahrenheit desirable, refrigeration essential for any marketing period exceeding two days; refrigeration desirable for all marketing periods.

Effect of Low Oxygen.-- According to one investigator (8) a lowered O_2 content of the air is beneficial down to about 3 per cent at 68 degrees Fahrenheit, below this point injury occurs. The limit is lower (about 1 per cent) at 50 degrees Fahrenheit. Low O_2 injury is characterized by longitudinal depression in the upper region of the stalk. Heavy wax coatings can also cause this injury. It has been shown (10) that low O_2 contributes to the retention of ascorbic acid by asparagus at temperatures of 50 degrees Fahrenheit and 68 degrees to 73 degrees Fahrenheit.

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Effect of High Carbon Dioxide.-- It has been reported (2) that a CO_2 content of 25 to 30 per cent was beneficial at a temperature of 60 degrees to 70 degrees Fahrenheit if the holding period was limited to one day. If the time was prolonged to two days, then the result was sometimes harmful. Concentrations of 40 per cent for one day were harmful. Platenius and others report that a concentration of 28 per cent was not harmful when prolonged for a three-day period at 32 degrees, 39 degrees, 50 degrees, or 59 degrees Fahrenheit. Others reported that 50 per cent was harmful at all temperatures. Injury consisted of the development of water-soaked areas or a browning of the outer bud scales. Both Platenius (10) and Thornton (15) state that adding CO_2 to the storage atmosphere at room temperature results in an increased rate of ascorbic acid loss. However, Platenius states that at 50 degrees Fahrenheit, added CO_2 results in better retention of ascorbic acid.

Magnitude of Respiration.-- Asparagus has one of the highest rates of respiration of all vegetables. The rate decreases during storage. Following are some approximations based on data of Platenius (7). Asparagus trimmed for prepacking would have a higher respiration rate than indicated here.

Temperature	Mgr. CO_2 per Kg.-Hr.	B. t. u. per ton per day	Pounds of ice per ton per day
Degrees Fahrenheit			
75	300	66,000	458
50	150	33,000	229
33	45	9,900	69

Preparation for Packaging.-- Washing, trimming, and removal of excess water would be necessary. Immediate cooling to near 32 degrees Fahrenheit would be desirable.

Elimination of Weight.-- It is estimated that 25 to 50 per cent of the weight of asparagus could be eliminated for prepacking.

Effect of Packaging.-- Cellophane bags inverted over regular bunches of asparagus were used on a trial basis in a shipment of California asparagus to New York City in 1934 (11). Two grades of cellophane were used; both lots showed condensation of moisture and some increase in mold and were not received favorably by the trade. These results are of limited application to the present problems of consumer packaging, but may be indicative. It would appear that the packaging of asparagus could be either beneficial or harmful. Injury from low O_2 would seem very likely unless precautions were taken to avoid this.

Platenius (9) has reported that none of the films used for packaging are sufficiently permeable to O_2 to permit normal respiration by asparagus if the package is sealed.

Conclusion.-- The prepackaging of asparagus would appear to offer possi-

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bilities. However, injury due to low O_2 and high CO_2 might occur. Closure of bags by stapling is probably desirable. If the bags are closed tightly, vent holes should be provided until found unnecessary. Immediate cooling followed by continuous refrigeration to the consumer would be desirable. Experimental tests are needed and should include appearance, taste, and nutritive content.

Cauliflower and Broccoli

Storage Life.-- Two to four days at 70 degrees Fahrenheit; eight to twelve days at 50 degrees Fahrenheit; and thirty to sixty days at 32 degrees Fahrenheit.

Causes of Deterioration.-- Water loss, decay, yellowing of broccoli, browning of cauliflower.

Storage Requirements.-- High humidity and 32 degrees Fahrenheit optimum.

Effect of Low Oxygen.-- Somewhat beneficial in retarding loss of ascorbic acid in broccoli (10). A lowered O_2 content of the air probably advantageous down to about 5 per cent.

Effect of High Carbon Dioxide.-- A short exposure (two days) to concentrations of 30 to 50 per cent have shown no harmful effect on broccoli or cauliflower (2). Thornton (14) has shown that cauliflower will tolerate 25 per cent CO_2 for one week at 32 degrees, 39 degrees, and 50 degrees Fahrenheit but 50 per cent was harmful.

Magnitude of Respiration.-- No data are available for cauliflower. The respiration rate of broccoli is very high -- see asparagus rates for an approximation.

Preparation for Packaging.-- Trimming, possibly washing, segmentation of cauliflower.

Elimination of Weight.-- Very little in case of broccoli; up to 50 or 60 per cent in case of cauliflower.

Effect of Packaging.-- Pliofilm wraps and bags have been reported to be of benefit (13). Tests in retail stores in Ohio (4) indicate that packaging extends the "shelf life".

Conclusions.-- For long marketing periods the containers should not be sealed unless tests show that this is feasible. Long-distance shipment of these vegetables should be preceded by careful tests. Packaging of these commodities for local distribution can probably be practiced safely on the basis of what is now known.

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